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OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR, C. A. CHANT ASSISTANT EDITOR, F. S. HOGG

David Dunlap Observatory
Richmond Hill P.O., Ont.

ASSOCIATE EDITORS:

C. S. BEALS
Dominion Astronomer
Ottawa

J. A. PEARCE
Dominion Astrophysicist
Victoria, B.C.

A. THOMSON
Controller of the Meteorological Service of Canada, Toronto

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THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

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Visitors to Toronto who wish to get in touch with the Society are invited to telephone:

General Secretary—Mr. E. J. A. Kennedy, ELgin 7656.
Assistant Secretary—Mrs. E. Todd, KIngsdale 3419.

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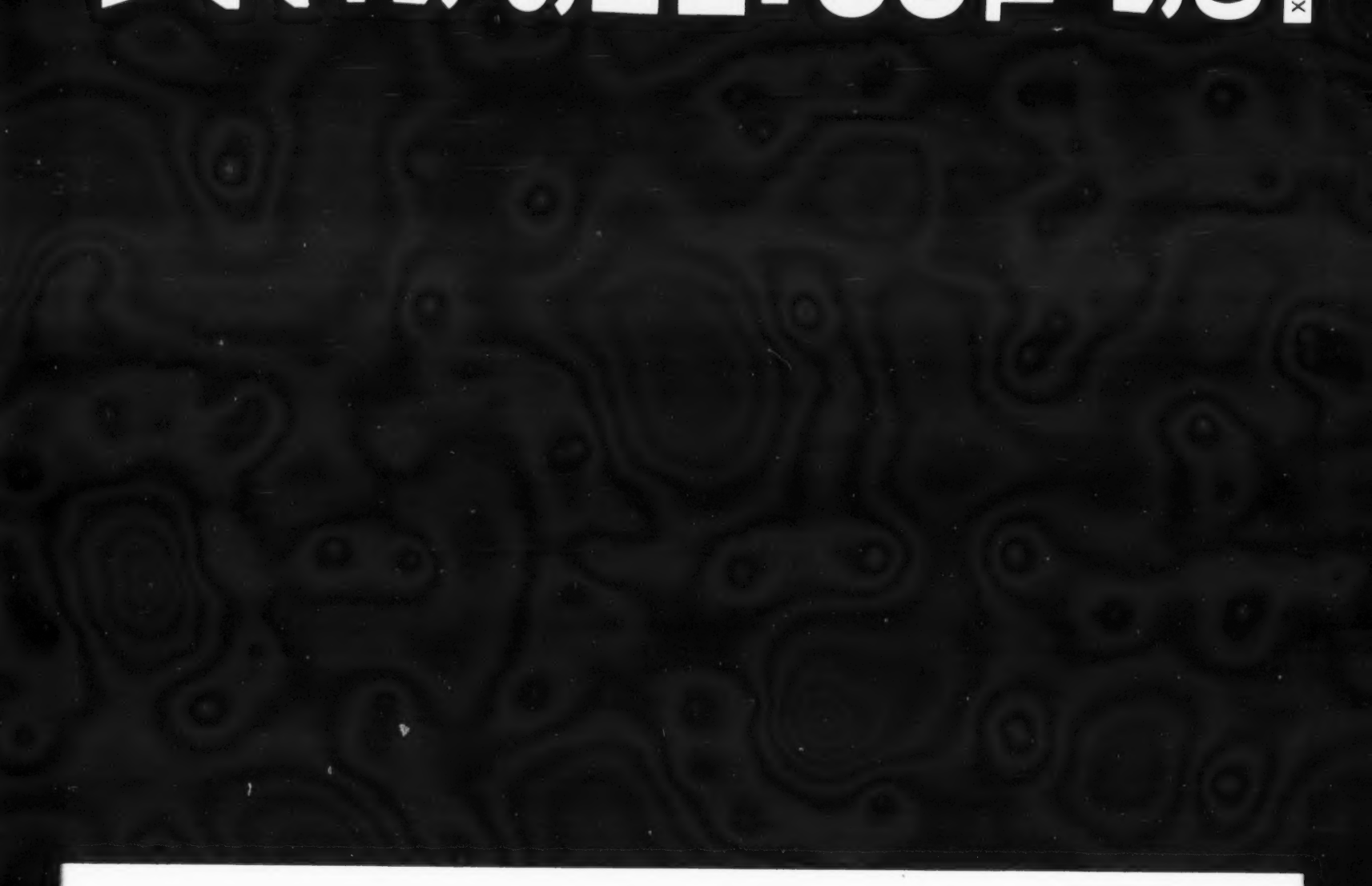

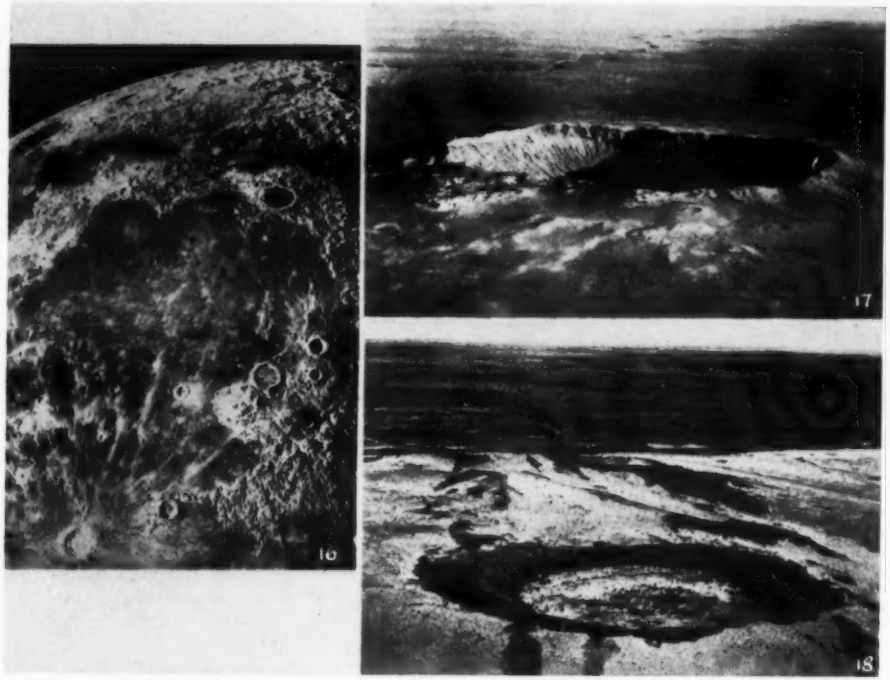

FIG. 16—Craters on the moon showing the radial markings. *Photograph by Mount Wilson Observatory.*
FIG. 17—Canyon Diablo Crater, Arizona. *Photograph by Clyde Fisher.*
FIG. 18—Wolf Creek Crater, north-western Australia. *Photograph by The Vacuum Oil Company, Australia.*

X

PLATE IX

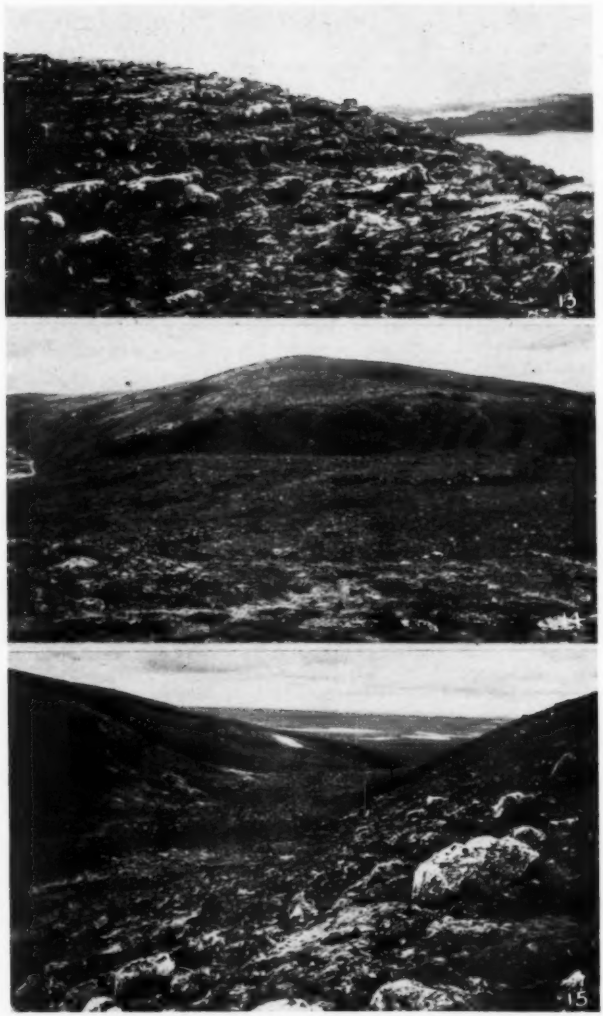

FIG. 13—Jointed granite bed-rock on the southern rim. Note the joint planes dipping at 15° outward.
FIG. 14—Large rift through eastern rim between the two highest points.
FIG. 15—Large rift through north-eastern rim. *Photographs by V. B. Meen.*

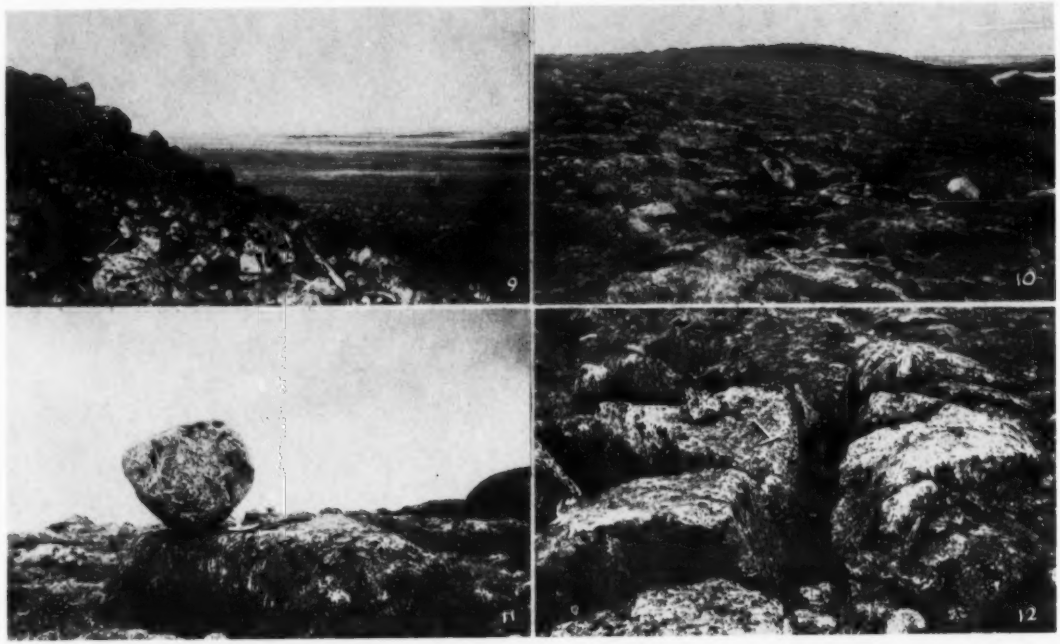

FIG. 9—Outer slope near top of rim, north-western side.
FIG. 10—Broad, gently curved top of rim. Much of rock shown is jointed granite bed-rock. Looking west on southern rim, crater to right.
FIG. 11—One of numerous fragments of granite deposited on the top of the rim. Lichen causes the nearly white granite to appear dark blotched.
FIG. 12—Jointed granite bed-rock on top of crater. The large joint in centre is a radius of the circular crater. The circumferential jointing is shown at right angles to it. *Photographs by V. B. Meen.*

FIG. 3.—Chubb Crater as seen from Museum Lake to the north-west. *Photograph by R. C. Hermes.*
FIG. 5.—Granite fragments which litter the plain outside Chubb Crater. *Photograph by V. B. Meen.*
FIG. 7.—Inside slope of crater rim. *Photograph by V. B. Meen.*
FIG. 8.—South-eastern portion of rim from edge of Chubb Crater Lake. *Photograph by F. W. Chubb.*

PLATE VI

FIG. 1—Aerial photograph from 20,000 feet of Chubb Crater and Museum Lake. *Royal Canadian Air Force photograph.*

FIG. 4—Chubb Crater, looking south-west across the highest part of the rim. The hollow to the right of the high point is the rift shown in figure 15. *Photograph by V. B. Meen.*

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CHUBB CRATER, UNGAVA, QUEBEC*

By V. B. MEEN

(with Plates VI-X)

ON July 21, 1950, I set foot on the rim of a gigantic crater in Canada's sub-Arctic. This crater is far larger than the famous crater in Arizona, and from observations which I made I am convinced that it too is of meteoritic origin.

This crater is in the north-western tip of Quebec province in the region known as Ungava. It has the coordinates 73° 40′ west longitude and 61° 17′ north latitude (ECN = + 737, 613).

It was hard to believe that I was really at the goal at which I had been headed for so many months. In February, 1950, Mr. F. W. Chubb, a prospector, had called my attention to a set of aerial photographs taken by the Royal Canadian Air Force in 1946, on which a crater-like lake was recorded (see figure 1). This lake was also marked on the Povungnituk River sheet of the Hydrographic and Map Service, Department of Mines and Technical Surveys, Ottawa, 1949 Edition, and was labelled "crater". In fact, as I discovered later, the crater had first been photographed in the early part of the second world war from a United States Air Force aeroplane during a routine weather flight.

On these maps, the lake was shown as 10,000 feet in diameter and by measurements of the photographs a height of 500 feet was estimated for the rim. The fact that a high rim surrounded the lake

*All republication rights reserved to Dr. V. B. Meen, Director of the Royal Ontario Museum of Geology and Mineralogy.

ruled out the possibility that the lake occupied a sink-hole caused either by the melting of a buried block of ice after the ice age or by the dissolving away of limestone rocks in a subterranean cavern, the roof of which had finally collapsed.

This left only two other possible causes for the crater. It must be either an extinct volcano or a meteorite crater. The fact that the crater showed most remarkable symmetry indicated that it was post-glacial in origin or at best occurred during the final stages of the ice age when no movement of the ice was taking place. Since no volcanic rocks or signs of volcanic ash had been noted in that part of Quebec or along the coast, I did not consider it likely that the crater was of volcanic origin. This left a meteoritic origin as the most likely but a crater so large was almost unbelievable and almost too good to be true.

Mr. Chubb, however, hoped for a volcanic origin. He knew that diamonds occur in extinct volcanos in South Africa and he hoped that this crater might indicate such conditions. His hopes were boosted further by the fact that diamonds have been found in the United States in gravels which were transported there by glaciers which originated in north-eastern Canada.

Immediately Mr. Chubb and I began a search for funds sufficient to carry us to this distant spot in order to make a study of the crater, determine its origin and stake it if it proved to be volcanic.

It is not the place here to detail the troubles we had in raising the funds and at the same time keep the story quiet in order to protect Mr. Chubb's interest. It is sufficient to say that finally we secured enough money to purchase our equipment and pay the living expenses of Mr. Chubb, myself and a photographer,[1] and The Globe and Mail publishing company had offered to furnish the transportation in their Grumman Mallard, an amphibian aeroplane capable of carrying eight passengers in addition to the pilot and engineer. It should be recorded that it was through the efforts of Mr. K. W. MacTaggart, special correspondent of *The Globe and Mail,* that most of the finances[2] and the offer of the plane were obtained.

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[1]Mr. Robert C. Hermes, Buffalo, N.Y., artist, naturalist and photographer, donated his time in order to photograph the expedition and its findings.

[2]The finances were supplied by five alumni of the University of Toronto, and by a well known Toronto mining man, all of whom wish to remain anonymous.

On July 17 we took off from Malton airport. Bad weather delayed our trip and it was not until Friday, the twenty-first, that we re-fueled at Fort Chimo on the south end of Ungava Bay and headed north-west on the last lap of our journey. The crater is located about 290 miles north-west of Fort Chimo and a total of about 1700 miles by air on the route we had followed from Toronto (see figure 2).

It was a brilliant, hot summer day. As we had flown north over Labrador and Quebec we had noticed that the trees were becoming fewer and at Fort Chimo their stunted character was apparent. About

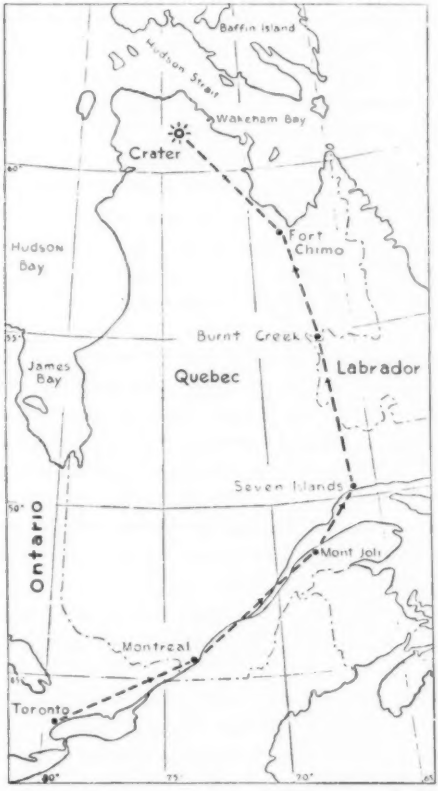

FIG. 2—Location of Chubb Crater and route taken by Royal Ontario Museum—Globe and Mail expedition, July 1950.

ten miles north-west of the air strip, the trees disappeared completely and the country became entirely barren.

The magnetic declination in this part of Canada is between 40° and 45° west and so as we flew north-west our plane pointed nearly due north magnetic. After about an hour and twenty minutes, a low hill (figure 3) appeared dead ahead and, as we approached at about 8,000 feet elevation, the hill appeared to open up and disclose a lake in its interior. It was our crater, our goal of five months! (See figure 4).

We circled the crater twice, taking pictures and then headed for a fairly large lake to the north where we made a landing. Neither of these lakes had been previously named and since returning home I have requested that the Board of Geographical Names of the Dominion Government name the crater Chubb Crater Lake and the lake to the north-west where we landed, Museum Lake.

Fortunately, there was a sand beach at the south end of Museum Lake nearest to the crater and above the beach was a piece of flat ground relatively free of boulders and covered with reindeer lichen. With the exception of this small area, about 150 yards long by 25 yards wide, the country as far as the eye could see was covered with large fragments of rock, most of which were too heavy for one man to lift.

A sectional canoe was part of the equipment of the plane and as soon as we had landed it was assembled and launched so that a suitable anchorage could be located for the plane. The equipment was ferried ashore and camp established above the sand beach.

Chubb and I waited only long enough to pitch our tent and have a bite of lunch. Then we started for the crater. As mentioned above, the ground was covered with large fragments of rock and the walking was extremely difficult. There was practically no soil and therefore very little vegetation (figure 5).

No tree or shrub grows in the land, and no plant was seen which had a height greater than six inches. The most common plants were reindeer lichen, crowberries and moss campion, while two small clumps of Iceland poppies were observed. No mammals were seen and very little evidence of any was noted. The most common birds were the snow bunting and the American pipit, but we also saw one or two each of the common loon, Canada goose, rough-legged hawk, gull, ptarmigan, Lapland longspur, and northern horned lark. Lake trout

were caught in Museum Lake, trout minnows were seen in a small pond near the crater, and one minnow was seen in the crater lake. The comparative lack of insects was a pleasant surprise. There were a few mosquitoes, black flies, gnats, crane flies, caddis flies and a tiny black spider. The earliness of the season may account for this scarcity. According to Flying Officer Robert Burns, commanding officer of the R.C.A.F. detachment at Fort Chimo airport, it was the first warm day they had had.

Snow still remained in many places on the north slopes of the crater rim and a few miles to the north it could be seen on the *south* slopes of high hills. While Museum lake and all the other lakes of the area were free of ice, Chubb Crater Lake was three-quarters covered with floating ice three feet thick! Since returning home, I have obtained two photographs taken in late August, 1949, from a plane which flew past the crater, and these show the crater lake free of ice but the ground covered with snow. It is also reported by the Royal Canadian Air Force that a number of their smaller planes have landed in the crater when it was ice free. The period, however, when such landings can be carried out, or in fact when a study of the crater under reasonable conditions is possible, is very short. The ground was found to be frozen at a depth of less than twelve inches below the surface and this would suggest that it remains frozen continuously.

Near the shore of Museum Lake at a distance of about two miles from the nearest rim of the crater, there were a few boulders of several kinds of rock mixed with the granite boulders. As we approached the crater these types of boulders became fewer and on the crater were absent except for some fragments of a dark coloured rock known as diabase which will be mentioned again later.

I made three trips to the crater and on the last I made a complete circuit of the rim (figure 6). The crater is to all appearances perfectly circular. When a topographic survey is completed, we may find that the lake is slightly elliptical but there is no hint of that to the eye. On each of the three maps on which the lake has appeared, the lake has been shown successively larger and in the most recent edition is shown as 10,000 feet across, and pentagonal in shape! This can only be the cartographer's instinctive reaction that no body of water could be so round. It must be added that the cartographer had pictures taken from one side only while we have dozens taken from

all directions and have examined the lake itself. Until an actual survey is made we must assume the dimension of 10,000 feet given on the map to be essentially correct.

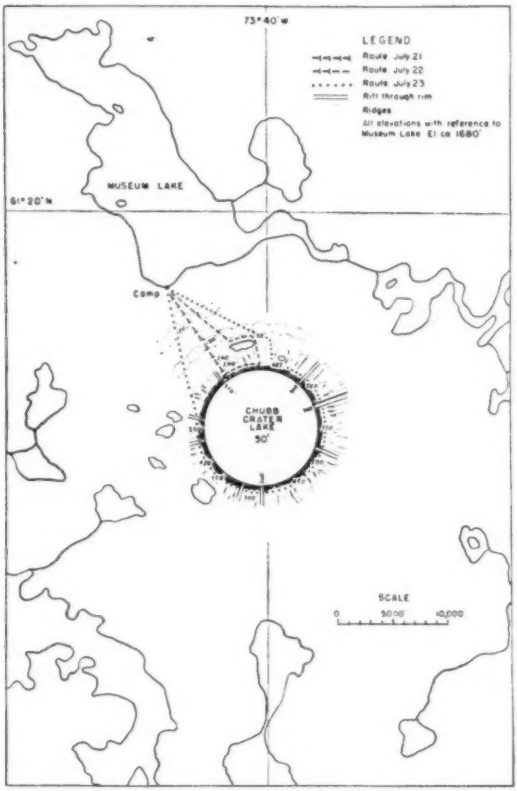

FIG. 6—Sketch of Chubb Crater and the vicinity, showing the area which has been examined. The location of the small ponds west of the crater and the extension of the pressure ridge east of the lines of traverse, were obtained from photographs. *Photograph by V. B. Meen.*

The rim rises out of the lake at an angle of approximately 45° (figures 7 and 8) at all points except one. On the east side there is a short section where the slope is not so steep but approximates 30°. The outside of the rim varies considerably in steepness from place to

place but averages about 25° (see figure 9). Towards the top of the rim the slope decreases and flattens off into a broad, slightly curved top (figures 10 and 14). This is so broad that when we stood on the highest part we could not see the contained lake or the outer plain.

At first approach the rim appeared to be a jumble of broken blocks of granite dropped at random into their present positions. On more thorough examination I became convinced that the rim represents a mass of granite bed-rock which has been fractured by a tremendous explosion and has been lifted bodily to its present position.

It is inconceivable that such a rim could have been formed by any weathering process and left standing 300 to 550 feet above the surrounding plain. Many random fragments of granite (figure 11) are observed on the top of the rim but bedrock can be observed almost continuously.

Fracturing or jointing has taken place in three directions at approximately right angles. These are radial, circumferential and nearly horizontal, dipping outwards at about 15°. Figures 12 and 13 show these features and such scenes can be duplicated at will on the crater rim. The blocks so formed are usually separated by several inches and their edges and corners are rounded off.

The elevation of Museum Lake was determined to be 1680 feet above sea level by comparison with altimeter readings made at Fort Chimo. This elevation was used as a basis for comparison in studying the crater where all readings of elevation were made with a pocket aneroid. The crater rim rises 300 to 550 feet above Museum Lake.

The highest part of the rim consists of two high points shown in figure 4, each about 550 feet, separated by a valley or rift whose bottom was about 350 feet. This high section was on the east, slightly north of the east part of the rim. The opposite side of the rim was in general the lowest portion, although the very lowest part was nearly the most southern portion where a narrow rift through the rim had an elevation of about 260 feet. Directions and locations were determined by means of a Brunton compass and back sights on the original point of access to the rim.

As was indicated above, great valleys or rifts occur in the rim and run radially outwards. Some of these are only forty to fifty feet deep while at least two are about two hundred feet deep. The latter are about 3,000 feet apart and cut through the highest part of the

rim on the east side. One of these appears in figure 14 between the two highest points, while the other is shown in figure 15. Snow still lay in a number of these rifts and in one case the water from the melting snow was running into the crater and out into the plain. The approximate positions of the major rifts are shown on the sketch, figure 6.

The water level in the crater is approximately fifty feet above that in Museum Lake. A few feet of shallows exist, probably due to action of the surface ice, and then the water drops off apparently resuming the 45° slope of the rim above the water. Due to fear of leaving our aeroplane unprotected, and our inability to take our one canoe overland, down into the crater and back in one day, no soundings were obtained. An eerie stillness, accentuated by the tinkling of moving ice, adds to the awe induced by the shape and great size of the crater. The wind, blowing continuously across the top of the crater, is the apparent cause of a distinct vibration in the air.

The land outside the crater slopes at about 25° to an elevation of about 300 feet above Museum Lake. From here outward the slope is much more gentle and in general is a talus slope made up of fragments which have been thrown from the crater.

At about three-fifths of a mile, and again at one mile from the north rim, ridges of jointed bedrock rise out of the general level of fragments. These are thirty-five to fifty feet high and show joints pointing toward the crater and at right angles to this direction. The third joint plane is steeper than that shown on the crater rim. Similar ridges could be seen outside the crater at many points. While a study of the numerous photographs does not prove that these ridges are continuous around the crater, their positions seem to indicate a series of ripples or wrinkles either continuous or overlapping which do surround the crater. If this is so, the spacing may be interesting. From the centre of the crater to the rim is approximately one mile, to the first major ripple one and three-fifths miles and to the second ripple two miles (see figure 6).

A number of small ponds, nearly round in shape but one elliptical, are located on the more gentle outer slope adjacent to the bottom of the steep portion. These may be ordinary hollows filled with water, but each appears to have a rim of fragments around it. The elliptical pond, which was the only one I observed in detail, had a definite rim, including bedrock on its outer edge and the rim was higher

at the east than at the west end, similar to the main crater. The long axis of the elliptical pond was east-west. Although it was shallow near the edges, the deep blue colour of the water and the inability to see boulders in the centre, even from the top of the main rim, indicate considerable depth.

As mentioned earlier, the only materials located on top of the crater rim, other than granite, were fragments of diabase weathered brown on the outer surface. This is a well-known igneous intrusive rock. A few fragments were seen on the north rim and in the plain to the north, and one was picked up near the shore of Museum Lake. There were many fragments on the east part of the rim and on the south-west to west portions. It is likely that a tabular body, more or less vertical, of this diabase cut across the granite in an east-west direction near what is now the south rim and was fractured by the blast, raised and ejected along with the granite. No diabase was seen in place.

No fragments of any recognized meteoritic material were observed. The search, however, was brief and, in addition to the rim, covered only a triangular area with its apex at camp on Museum Lake and its base of about one and one-half miles on the nearest portions of the rim. Most of the area beyond the rim was not examined as is shown in figure 6.

In summing up, we may say that the evidence points to a meteoritic origin. No sign of vulcanism is present. Joints and tilting of joints indicate that a tremendous explosion took place. The ridges outside the rim itself may indicate shock or compression ripples similar to those produced in calm water when a stone is dropped in. The rifts through the rim may be the directions along which extra forces carried materials during the explosion. This would be similar to the splatters produced by high explosives when detonated on the ground. The radial markings on the moon are thought by many to have been formed by the material so transported and are shown in figure 16. The high rim at the east and low rim at the west gives rise to the thought that the meteorite travelled from slightly south of west to slightly north of east. The small ponds flanking the crater may be caused by fragments which accompanied the major mass or broke off it in the flight through the atmosphere.

No sign of glaciation was seen on or around the crater itself. Since the crater has not been deformed or filled in, it was probably

produced after the close of the ice age. The amount of exfoliation or peeling off of layers of the granite from the fragments, thus producing very much rounded forms, nevertheless indicates a considerable age. It is probably safe to say that the age lies within the limits of 3,000 and 15,000 years. The fact that there is no knowledge of or legend concerning the crater, and no mention of a big explosion or bright light among the Eskimos of the district has relatively little value since the Eskimo has been in this part of Canada only a few hundred years.

If this is a meteorite crater, and the evidence appears very strong in support of this conclusion, it is very much bigger than any other known meteorite crater. Table I gives a summary of the principal

TABLE I

Name of Crater	Type of bed rock	Diameter (rim to rim in feet)	Depth in feet	Height above surrounding plain	Approximate circumference Mi.	Approximate Area, Acres	Comparative size based on area
Chubb Crater	Granite	11,000	*500+	300-580′	6.6	2240	7
Canyon Diablo	Sandstone & Limestone	4,150	575	130-160′	2.5	320	1
Wolf Creek	Sandstone	2,700	200	Up to 100 ft.	1.6	125	0.4

*Depth of water unknown.

features of Chubb Crater in comparison with the Canyon Diablo Crater, Arizona, figure 17, and Wolf Creek Crater, north-west Australia, figure 18. (See figure 19)

By comparison with the Canyon Diablo Crater, Chubb Crater could be more than 1,500 feet deep. Even assuming a depth of 1,000 feet, the weight of granite removed from the crater by the explosion exceeds five billion tons.

Although Chubb Crater is apparently the first in which the fracturing of the bed rock has been clearly exposed and in which the radial rifts in the rim have been observed, a radial arrangement is apparent at the Canyon Diablo Crater, if the map published by

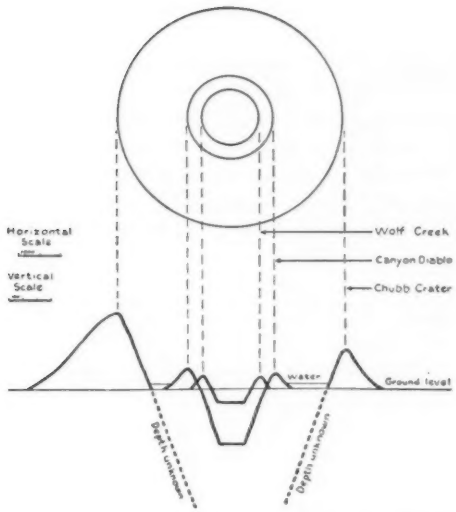

FIG. 19—Diagramatic comparison of Chubb Crater, Ungava, Quebec; Canyon Diablo Crater, Arizona; Wolf Creek Crater, north-western Australia.

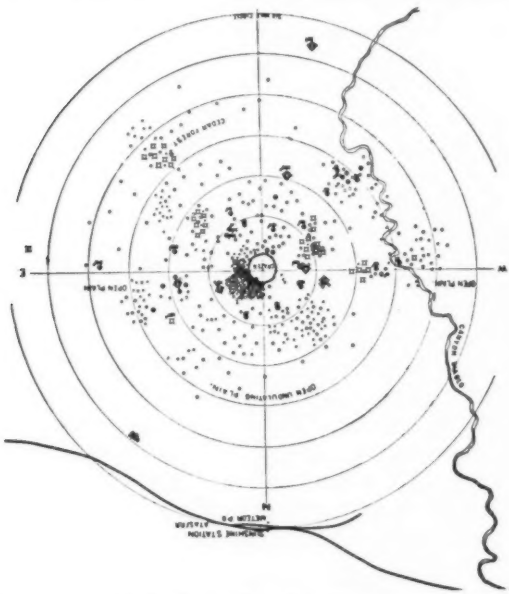

FIG. 20—Map showing distribution of meteorite fragments around Canyon Diablo Crater, Arizona. A definite concentration of material along zones radiating from the crater is apparent. *Sketch by D. M. Barringer.*

D. M. Barringer* of the location where the fragments of meteorite were found is accurate. A reproduction of this map appears as figure 20 and the grouping of the fragments is definitely asterate.

The 1950 expedition was small in personnel and the time of study was short. However, it did ascertain the major facts about Chubb Crater and supplied the information on which another expedition, larger in staff and capable of remaining for a much longer period, can be organized.

*Barringer, D. M., "Meteor Crater", a paper read before the Natural Academy of Sciences, Princeton University, Nov. 16, 1909. Privately published.

Royal Ontario Museum of Geology and Mineralogy,
100 Queen's Park,
Toronto.

DEDICATION OF THE "BRYDON" TELESCOPE

By Eluned Williams

VICTORIA Centres' 4-inch refracting "Brydon" telescope was officially renamed and dedicated on April 26th.[1] For this ceremony more than fifty members and friends gathered in the dome which houses the telescope and is located on the grounds of Mr. and Mrs. Robert Peters. Dr. J. S. Stevenson, President, introduced Dr. Joseph A. Pearce, Director of the Dominion Astrophysical Observatory, who spoke briefly on the history of the Brydon telescope. The instrument was dedicated to the society by Dr. R. M. Petrie, Honorary President of the Centre and the Assistant Director of the Observatory. Unfortunately, the sky was overcast so that the members were unable to look through the 4-inch refractor. However the instrument was open to inspection and Mr. Peters demonstrated its operation. Later a delightful lunch was served by Mrs. Peters. A vote of thanks to Mr. and Mrs. Peters for their hospitality was extended by Mr. P. H. Hughes. Members of Victoria Centre are indeed fortunate in having such a splendid instrument and such capable guidance as that offered by the Director of Telescopes, Mr. Peters.

The addresses of Dr. J. A. Pearce and of Dr. R. M. Petrie are printed below.

History of the Brydon Telescope by Dr. J. A. Pearce

It is a pleasure to participate in this celebration, and a privilege to say a few words about Mr. H. Boyd Brydon, a former President of our Society, in whose memory we are naming this telescope.

Astronomy is fortunate in having many enthusiastic amateurs, who with their modest instruments make observations of value and thus contribute to the advancement of our science: cultured and gifted men, animated with a desire to share their knowledge of the wonderful universe with others. Such men accomplish a great deal in popularizing astronomy by their popular lectures, radio addresses, and publications. Mr. and Mrs. Brydon opened their home and observatory to their friends and thus made a great contribution to the culture of their community. We, who knew and highly respected him, realize that H. B. Brydon was the ideal amateur astronomer.

[1] *J. R. A. S. Can.*, Volume XLIII, Number 6, 1949.

We should be proud of this splendid little refractor with its interesting seventy-year history of accomplishment in revealing the wonders of the sidereal heavens. It was purchased from Wray and Co. of London in 1882 by Mr. Allan F. Miller, an amateur astronomer of Toronto. You know, of course, that our Society is almost as old as the Dominion of Canada, for it was organized by Andrew Elvins in 1868, and flourished for forty years as the Toronto Astronomical Club, and later as the Astronomical and Physical Society of Toronto before, under Dr. C. A. Chant's fostering aegis, it received a Royal Charter.

At the time when Sir William Huggins was the first astrophysicist in England making the initial survey of stellar spectra, Allan F. Miller was, in Canada, our first astrophysicist. He equipped his telescope with a Browning universal spectroscope, a grating ruled by Rowland and obtained from Dr. J. A. Brashear, a filar micrometer and other accessories. He was the first person in Canada to see solar prominences, and to study and photograph the solar spectrum. For over thirty years he communicated papers to our Society on the spectra of the stars, of the nebulae, the spectrum of the eclipsed moon, etc. Among his papers published in our *Transactions* is one entitled "The Spectrum of Light Emitted by Insects." I believe this was the first attempt to study spectroscopically the cold light emitted by fireflies: Mr. Miller had a passion for observing, he knew the starry skies thoroughly, so it will not surprise you to learn that he independently discovered both Nova Persei in 1901 and Nova Aquilae in 1918, and communicated interesting articles on the spectra and light variations of these temporary stars.

Those were interesting meetings of the Society, when as Recorder in 1919-1922, I reported the addresses of Dr. C. A. Chant, Allan F. Miller, A. F. Hunter, Dr. A. D. Watson, physician and poet, John A. Paterson, the eminent lawyer and eloquent historian. These men were amateurs all, with the exception of Dr. Chant, and they wisely laid a firm foundation for our national Society.

Then Mr. Miller lost his sight. What a tragedy for an astronomer, yet he, like Dr. E. B. Frost, Director of the Yerkes Observatory, bore this affliction courageously and cheerfully. He was concerned about his astronomical equipment, wishing it to be used and therefore welcomed my suggestion that he sell his telescope to Mr. H. Boyd

Brydon, a retired engineer who had come to reside in Victoria in 1925, and who was desirous of taking up astronomy as an avocation.

Thus about 1926 the Oak Bay Observatory was established, and Mr. Brydon became associated with our Society, advancing through all the offices from Secretary to President of the Victoria Centre, and to be the first Vice-President of our national Society. Because of ill health he declined the Presidency, which was a great pity for he justly deserved the honour.

For some fifteen years Mrs. Brydon's lovely home and the observatory were the centre of the Society's activities. Council meetings and special meetings were held there. I recall about twenty years ago giving a series of weekly lectures on mathematical astronomy to a small but interested group of which our Vice-President, Mrs. J. R. Noble, was the star pupil. The first of our popular "Summer Evenings with the Stars" course was held under the starry skies on the lawn beside the observatory; Mr. Brydon, Bob Peters, Capt. Phillip Hughes and others being the speakers. This course of elementary lectures, for which Mr. Brydon was largely responsible, has been given for nearly twenty years, and has been adopted as a valuable means of recruiting membership by other Centres of our Society.

Mr. Brydon was fond of observing the moon, planets, and double stars, but did not undertake a heavy programme of observing variable stars. He observed the outburst of Nova Ophiuchi No. 3 in 1933, following the fading star to the limit of visibility of his telescope, and published a light curve in our JOURNAL. He had an excellent knowledge of the history of astronomy, read many of the current periodicals, and was well informed on all phases of observational astronomy. His lectures and addresses were therefore always interesting and informative. His most valuable contribution was the series of seven or eight well-illustrated articles published in our JOURNAL on the design and construction of small observatories, telescope mountings for amateurs, clock drives for small telescopes, and the mounting and adjusting of equatorial telescopes. For his observations, his contributions in popularizing astronomy, and especially for his many publications on observatories and telescopes for amateurs, the Council awarded him the Chant Medal in 1941. He wrote a series of thirty illustrated articles on popular astronomy which were published by the Daily Colonist, Victoria, B.C. shortly before his death.

Mr. Brydon generously donated the Observatory when the Society purchased the telescope in 1944 and permitted us, as formerly, to hold meetings at his place. In 1947 it was moved to its present location, and is under the efficient supervision of Mr. Robert Peters.

There it stands, our fine refractor, seventy years young, ready to reveal to us the celestial scenery of the heavens. Perhaps our Director of Observations will show us Saturn, a planet Mr. Brydon loved to view. If so, I predict that our junior observers will discover that planets really do have axes, for we will certainly observe what appears to be Saturn's equatorial axis, 177,000 miles long.

To me, this instrument will always be the Miller-Brydon telescope, but because of his outstanding contributions in popularizing astronomy in this City, it is very right and fitting that we call it the H. Boyd Brydon telescope, in his memory.

Dedication by Dr. R. M. Petrie

We have met here this evening to dedicate the Brydon telescope to its task of assisting our Victoria Centre in spreading astronomical knowledge. In a sense this instrument has been dedicated already through the devoted labours of Mr. Miller and Mr. Brydon, its former possessors. It is fitting, however, that we rededicate it in its new role of bringing to a wider circle knowledge and pleasure through the contemplation of the heavens. The telescope will be used also to stimulate an interest in our science among the younger members and their friends and so foster a continuing public interest in astronomy.

Victoria is fortunate in having this opportunity; fortunate, also, in having the experience and wisdom of such a mentor as our curator, Mr. Robert Peters. It is the hope of your committee, and council, that the Society will now make extensive use of the telescope to enlarge their astronomical experience with Mr. Peter's guidance.

In the name of the Victoria Centre of the Royal Astronomical Society of Canada, I hereby dedicate this, the Brydon Telescope, to its work of bringing instruction and pleasure to all who wish better to acquaint themselves with the glories of the skies.

Dominion Astrophysical Observatory,
Victoria, B.C.,
May, 1950.

PLATE XI

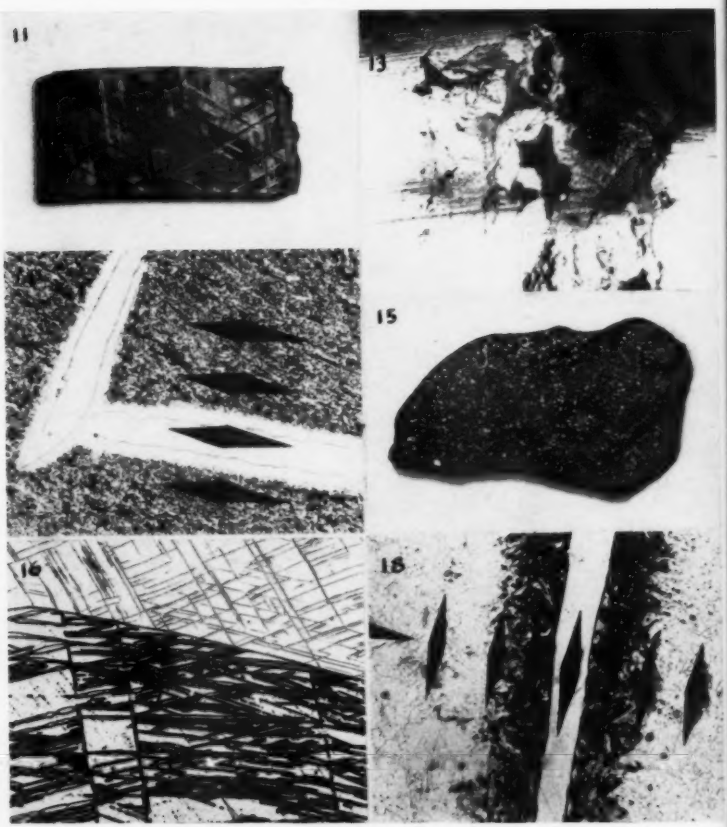

FIG. 11. Fine Octahedrite,—Bristol, Tennessee. Showing excellent Widmanstätten pattern, resembling an isometric tartan. (3/5x)

FIG. 13. Minute Carbonado Diamonds in Canyon Diablo Meteorite. Parallel lines are deep grooves caused by diamonds being uprooted and dragged across the surface of the specimen. Diamonds are indicated by arrows. (9x)

FIG. 14. Ataxite,—Tlacotepec, Mexico. Showing an inclusion of same hardness as basic material. (150x)

FIG. 15. Stony Meteorite,—Plainview, Texas. Showing myriad tiny flakes of nickel iron which are scattered through the mass. Hardness tests were made on many of these. (5/8x)

FIG. 16. *Stony Meteorite,*—Plainview, Texas. Large nickel-iron flake, evidently a twinned hexahedrite. (150x)

FIG. 18. Coarse Octahedrite,—Canyon Diablo, Arizona. An instance where a taenite border is softer (longer indentation) than the basic kamacite on both sides. (150x)

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MICROHARDNESS TESTING OF IRON METEORITES
(Continued)

By F. K. Dalton

(with Plate XI)

IN the January-February, 1950, issue of this Journal, and under the above title, the writer explained the classification of iron meteorites and described the method of microhardness testing with the Knoop diamond indenter, giving some of the test data in relative hardness of meteorite constituents obtained up to that time, indicating the significance and emphasizing the importance of the new information resulting from this investigation. The various materials which constitute iron meteorites were named and defined.

Conclusions reached from the first studies on this subject also were given in the earlier article. The tests showed that kamacite in Canyon Diablo meteorites becomes harder as it approaches the taenite borders and that these borders may be harder in their central regions than at their edges. Neumann lines in hexahedrites were found to be harder than the basic kamacite. The change in hardness of surface materials of iron meteorites, due to heating while travelling through the earth's atmosphere, was shown by a traverse graph through an altered zone and compared with an unaltered area.

This investigation has been continued and further interesting and useful information on hardness obtained. Traverses and distributed measurements have been made on other types of meteorites. The minute metal flakes found throughout stony meteorites have been successfully measured and the metal in stony iron specimens tested. Probably the most interesting feature of this part of the investigation is the correlation of test results on the various types of iron meteorites from which hardness comparisons appear and are shown by a graph, —the hardness-nickel content relations in both alpha and gamma iron in meteorites.

In this work, the Knoop diamond indenter and the Knoop scale of hardness for metals are used. Comparison was made with the well known Brinell and Rockwell scales. Moh's hardness scale for minerals has been mentioned but is not considered satisfactory for expressing the hardness of metals.

Octahedrites

Some of the results obtained on octahedrites, the variety of iron meteorite that shows Widmanstätten figures when etched, were given in the earlier article, on pages 6-9. Specimens from other falls have not shown such great contrast between the maximum hardness of taenite borders and the minimum of the basic kamacite as was found in the Canyon Diablo coarse octahedrite. Neither have such very hard inclusions been found in any other varieties that were tested.

Octahedrites are subclassified according to the width of the kamacite plates of the Widmanstätten figures, as follows,—

Coarsest	—	plates	2.5 mm. or wider,
Coarse	—	"	1.5 to 2.0 mm. wide,
Medium	—	"	0.5 to 1.0 mm. wide,
Fine	—	"	0.2 to 0.4 mm. wide,
Finest	—	"	narrower than 0.2 mm.

A medium octahedrite specimen from Henbury, Australia, showed basic kamacite from 185 to 200, Knoop, and taenite from 210 to 240. A troilite inclusion in this specimen has hardness of 194 to

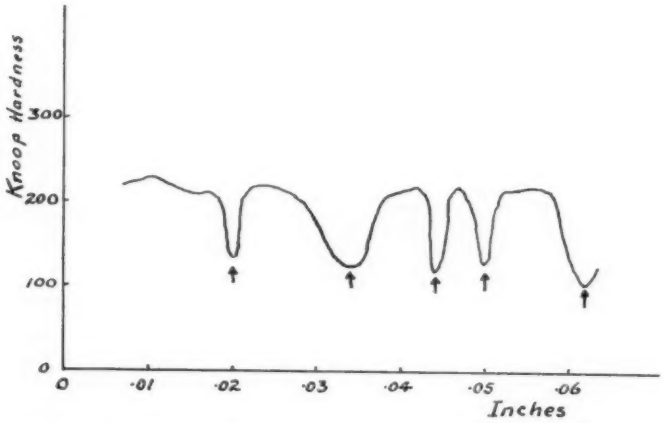

Fig. 12. Fine Octahedrite,—Bristol, Tennessee. Traverse test across several successive kamacite plates showing striking relative softness of taenite borders, marked by arrows.

196. Some high values, from 600 to 750 in one area and about 385 in another area, were neither in thin taenite lamellae nor in kamacite but seemed to be in some sort of inclusion or broad border band. The kamacite in this specimen, however, was so profusely covered with Neumann lines that test results in many areas were very confusing.

A specimen from Xiquipilco, Mexico, also a medium octahedrite, was of special interest showing a rare crystal twinning. Its basic kamacite was somewhat high, 250 to 270, and its taenite borders tested 410 to 430. The wide taenite border around a nodule was higher than the borders of the kamacite plates; it was measured at 560.

In the coarse and medium octahedrites, the taenite borders were harder than the basic kamacite plates. Tests on a "fine" octahedrite, however, from Bristol, Tennessee, figure 11, showed a very interesting reversal of this relation. The taenite borders were much softer than the kamacite, as shown by the graph, figure 12. Here kamacite measured about 220 while taenite was only 110 to 125.

Diamonds in Meteorites

Various materials are found as inclusions in iron meteorites. In many cases these are surrounded by borders of taenite, nickel-rich gamma iron. The hardest inclusions tested were of schreibersite, in Canyon Diablo specimens; these ranged in hardness from 1100 to 1360 Knoop. However, still harder inclusions are known in these meteorites, for diamonds have been discovered on several occasions. These are carbonadoes, or black diamonds, the amorphus variety without crystal form, and they are found in the schreibersite and other inclusion materials.

Such extremely hard substances as diamonds could not be tested, for two reasons,—they are too difficult to polish and also there would be considerable risk of damage to the Knoop indenter itself. In fact, the carbonado diamond is a very undesirable inclusion for it interferes seriously with the grinding and polishing equipment. As it projects from the surface of the specimen, refusing to be ground down, it will tear the emery papers or damage other surfaces used for polishing. Furthermore, the carbonado has a tendency to crumble or be uprooted in the polishing process and then it is dragged across the surface of the specimen cutting deep grooves, as shown in figure 13.

Nevertheless, there is something mysterious, something thrilling in finding diamonds that have come out of the sky, and in having the opportunity to examine them. Astronomy has gone far in proving that the chemical elements of this earth are known to exist throughout the universe. Here is an instance where their physical state can be compared and they are found to agree.

Ataxites

Nickel-rich meteorites which have a somewhat homogeneous structure and are practically featureless are known as "ataxites". Some meteorites with much lower nickel content, and which do not show either Neumann lines or Widmanstätten figures, are also placed in this category.

Tests have now been made on some ataxite material having a nickel content of approximately 17 per cent. It appears to be uniformly hard, the measured value being 292, which is much harder than the basic kamacite in hexahedrites or octahedrites.

These ataxites sometimes contain inclusions, as shown in figure 14, and it is interesting to note, from the length of the indentation, that these inclusions are of just the same hardness as the surrounding basic material.

The ataxite material tested had very good magnetic retentivity, and makes fairly strong permanent magnets for a nickel-iron alloy. Its magnetic strength, however, is not as great as that of modern aluminium-nickel-cobalt-iron alloys, produced artificially.

Nickel-Iron Flakes in Stony Meteorites

A cross-section study of stony meteorites, aerolites, reveals myriads of tiny flakes of nickel-iron throughout the mass, as shown in figure 15. The presence of these flakes provides a very reliable means of identifying this class of meteorite.

As these flakes are so minute, it is only by the Knoop indenter that their hardness can be measured. Tests now indicate that the flakes are all of equal hardness, 203 Knoop, the small flakes agreeing exactly with some relatively very large flakes found occasionally. The flakes, therefore, are slightly harder than hexahedrite material and of approximately the hardness of basic kamacite in octahedrites.

Particularly interesting results were obtained on a large flake in the Plainview meteorite, figure 16. Study of the structure in-

dicates that it actually is a twinned hexahedrite with two quite different widths of Neumann lines,—or different size of grain,—in the adjoining areas. A most peculiar result was obtained when microhardness tests were attempted in the more closely woven pattern, the darker part of the illustration. The Neumann lines there appear to be depressed, or even resilient, and the shape of the indentations was very irregular indeed.

Some X-ray photographs of one specimen were taken to show the distribution of the flakes through the mass of the slice, two of these exposures being so made as to give a stereoscopic pair which vividly illustrate the irregular scattering of the metal flakes at various levels, and concentration in some regions.

No microhardness tests have been made on the stony materials of these meteorites, the investigations being focussed on the physical characteristics of the nickel-iron in a variety of specimens in the different classifications.

Metal in Stony Iron Meteorites

There is a type of meteorite, known as "siderolite," which contains a varied amount of rock material with nickel-iron filling the interstices. In classification, they are between the iron and the stony meteorites. The iron inclusions are more massive than the flakes in the stony variety and are found as irregular claw-like and other forms. Some of the iron masses contain rock inclusions within themselves.

Very interesting tests were made on etched metal in a stony iron meteorite from Springwater, Saskatchewan. The contained rock inclusions were surrounded by borders of metal. A similar border appeared all along the edge of the metal mass where it had been in contact with the main rock material of the specimen. There were areas of basic kamacite. Various other areas in the metal had a grayish appearance and showed very delicate Widmanstätten figures near their edges.

There appear, therefore, to be three different degrees of nickel-iron in these metal inclusions. Three degrees of hardness were found on the tests. The basic kamacite measured 200 to 220, Knoop. The gray areas, showing crystal structure, range from 275 to 300. The borders, apparently taenite, run from 375 to 450. Thus the basic kamacite in the sample tested is slightly harder than the flakes of the stony type and the taenite agrees well with that in medium octa-

hedrites, whereas the gray areas, showing an average between the basic material and the taenite borders, indicates a crystal structure which includes both of the above materials.

These stony-iron meteorites evidently are not so frequently found as the individual iron or stony types. The opportunity to test them, therefore, is somewhat rare. They are not usually attractive in appearance and seldom are sold as collectors' specimens.

Correlation of Test Data

There are several objectives in this investigation. The first part was directed at determining, by traverse measurements, the variation in hardness of meteorite materials from point to point over the etched surfaces, particularly in octahedrites where the Widmanstätten pattern is evident. Some of the results obtained from these tests were given in the January-February JOURNAL.

The most interesting feature of the second part of this investigation probably is the correlation of data on the various types of meteorite tested to produce the new graph in figure 17, the Knoop hardness—nickel content relations in kamacite and taenite materials.

The writer did not make any quantitative chemical analyses to determine the nickel content in meteorites but rather is using the authentic values published in various approved reference books and reports as they apply to the different individual specimens upon which he has conducted microhardness tests.

There are two different forms of iron found in meteorites, i.e., alpha and gamma iron. These are distinguished technically as having body-centered and face-centered cubic crystal structures, respectively, according to the natural arrangement of the atoms within the lattice parameter, or unit crystal cube. Alpha iron is attacked by the common etching agents used for meteorites whereas gamma iron resists such chemical action. Thus kamacite is alpha iron with dissolved nickel up to about 30 per cent. Some meteorite authorities, however, prefer to consider the higher nickel solutions as composed of kamacite with varying proportions of plessite. Taenite, on the other hand, is gamma iron with nickel content from 13 to 45 per cent. in Canyon Diablo specimens.

The Widmanstätten structure in octahedrites is the result of precipitation of kamacite from the taenite at a temperature of about 905°C. The characteristic pattern is due to the crystallographic rela-

tion of the kamacite plates which are arranged, with regard to one another, as the faces of an octahedron. Whether the pattern appears triangular or rectangular on the etched surfaces depends upon the direction in which the meteorite is cut in relation to the crystal faces, these two patterns having been shown, respectively, in figures 2 and 3, in the earlier article.

Pure soft iron was measured and found to have a hardness of 100 Knoop. Pure nickel showed hardness of 220. The curves of figure 17, based upon the writer's measurements of hardness, were then derived as shown.

The kamacite line, starting at the left with pure soft alpha iron, at F, passes through hexahedrite material at H, ataxite material at A, and terminates at K. This may actually be the kamacite-plessite line according to some authorities, as already explained.

The point K was obtained by taking the highest value of hardness found in kamacite basic material, i.e., 430, in Canyon Diablo specimens, and plotting this on the basis of the maximum percentage of nickel which can be dissolved in alpha iron.

This curve, as may be expected, tends to turn downward, indicating that if it could be continued it would come down to the value of pure soft nickel at the right hand side of the graph, as indicated by the broken line.

The curve RS, from "Alloys of Iron and Nickel" by J. S. Marsh, gives the Knoop hardness of artificially produced nickel-iron binary alloys for different nickel content. The natural nickel-irons, kamacites, or kamacite-plessites, evidently are consistently softer than the artificial alloys, which difference most probably is due to the thorough annealing of the natural alloys during the inconceivably long period of very slow cooling through the transformation range, from gamma to alpha iron. The curve of artificial nickel alloys, however, is not consistent beyond about 25 per cent. nickel, which may be due alone to the impossibility of having sufficiently thorough annealing of these higher nickel alloys in the relatively very brief period of time permitted in factory production.

The taenite line represents gamma iron with nickel content. The softest taenite in Canyon Diablo specimens had hardness of only 175 Knoop, figure 18, whereas the hardest measured 803. The former value has been associated with the minimum nickel content known in gamma iron in these meteorites, 13 per cent., and the latter value with the

maximum nickel content, 45 per cent., and both were plotted, respectively at L and M.

Finding this very soft taenite, in view of information published in various authoritative scientific books and reports, was at first a decided surprise to both Dr. Nininger and the writer but it later

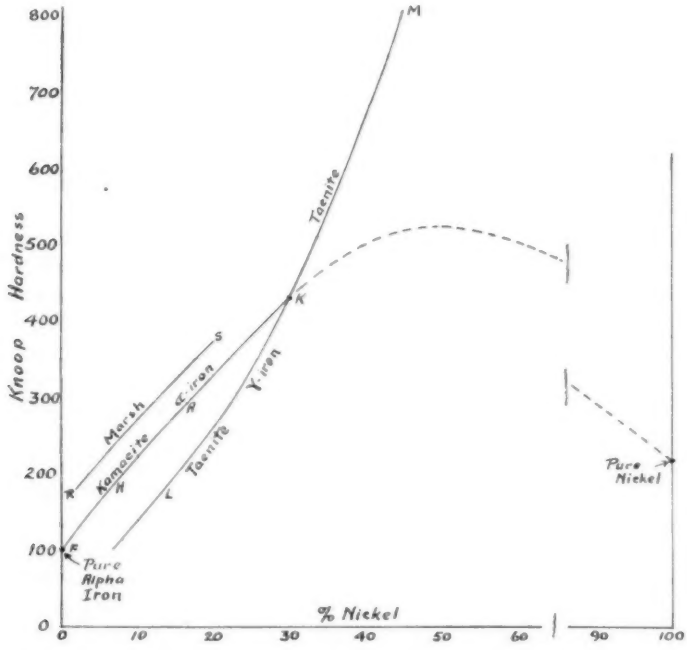

Fig. 17. Knoop Hardness—Nickel Content Relations in Metal of Meteorites.
F-K.—Kamacite basic material,—nickel-alpha-iron solutions, including hexahedrites and ataxites.
L-M.—Taenite border material,—nickel-gamma-iron alloys of octahedrites.

fitted into the picture as one of the most significant and important results of this investigation. Even softer taenite borders were discovered later in the fine octahedrite from Bristol, Tennessee, figure 12.

In the earlier studies of the Canyon Diablo meteorite, it was observed that kamacite plates increased in hardness toward contact with taenite borders, and also that these taenite borders continued to

increase toward their centre lines, figure 6 in the first article. It may reasonably be concluded that just at the contact surfaces in the meteorite both kamacite and taenite are of equal hardness and have the same nickel content. The point K, therefore, is common to both the kamacite and taenite lines in this graph. The taenite line then runs through L, K and M. As far as the measurements to date in this investigation indicate, M is the upper limit of this curve. In lower values, the curve suggests that taenite may have even lower nickel content than kamacite. For instance, the taenite values of the Bristol meteorite indicate lower nickel content than the kamacite, and lower than the softest taenite found in Canyon Diablo iron.

In medium octahedrites, there seems to be a gap between the nickel contents of the kamacite and taenite for any given specimen. In Canyon Diablo and similar irons, certain coarse octahedrites, the hardness and nickel content of the kamacite rises appreciably as it approaches the taenite borders. The changes in nickel percentage in medium octahedrites then must occur abruptly, without any graduated band of nickel content, or else such band must be extremely narrow indeed. It was observed through the miscroscope that there was no band of noticeable width between kamacite and taenite in specimens other than from Canyon Diablo.

Whereas nickel content in iron may be determined by quantitative chemical analyses, such tests give an average value and can not show variation from point to point unless samples for test can be procured in sufficient quantity and from the exact points selected. The quantity required for chemical tests usually spreads over a range of variation so that detailed information is not possible to obtain. By michrohardness tests and reference to the graphs of figure 17, however, the variation in nickel content may possibly be determined to a high degree of minuteness. The nickel content in very small areas, even variation in the tiny flakes of stony meteorites, may now be found by physical tests, through the use of such graphs.

The foregoing information and graphs are submitted for the consideration of those who study meteorites. They fit and can explain the results obtained on all varieties of specimens tested and studied so far in this investigation. Later studies probably will verify their accuracy and enlarge their application.

Some of the test results on typical meteorite specimens are given in the following tabulation,—

TEST RESULTS — KNOOP HARDNESS

Type and Location	*Kamacite*	*Taenite*	*Remarks*
Hexahedrite			
Mt. Joy, Pennsylvania,	180	—	Neumann lines harder than basic kamacite, i.e. 290.
Octahedrites			
Coarse;			
Canyon Diablo, Arizona,	190-430	175-803	Kamacite rises in hardness where it approaches taenite borders.
Medium;			
Henbury, Australia,	185-220	220-765	Kamacite covered with Neumann lines.
Xiquipilco, Mexico,	246-272	307-580	Rare twinned specimen.
Fine;			
Bristol, Tennessee,	200-240	110-125	Very soft taenite borders, Nickel content in taenite evidently lower than in kamacite.
Ataxite			
Tlacotepec, Mexico,	288-292	292	Excellent permanent magnet.
Aerolite			
Plainview, Texas,	186-220	—	X-ray stereoscopic photographs show density of flakes throughout mass.
Siderolite			
Springwater, Saskatchewan,	200-220	375-450	Intermediate gray crystal structure, —275-325.

In continuing this investigation, it is the intention to study more closely the materials found as inclusions in meteorites, namely, troilite, cohenite, schreibersite etc.

CONCLUSIONS

The additional studies have shown quite a variation in relative hardness of taenite and kamacite in octahedrites, from the very hard taenite and soft basic kamacite of the "coarse" Canyon Diablo specimens from Arizona to the extremely soft taenite with much harder basic kamacite in the "fine" octahedrite from Britsol, Tennessee. This reversal is very striking but appears to be in sequence of change from the "coarse" variety through the "medium" type to the "fine" octahedrites.

The tests on ataxites determine that, in hardness, they occupy a position of significance in relation to the kamacites of hexahedrites and octahedrites, and follow in sequence with increased nickel content in alpha iron solutions.

The delicate method of testing by the Knoop diamond indenter has permitted hardness information to be obtained on the tiny metal flakes in stony meteorites to show their position as hexahedrite materials, and their relation to kamacites in octahedrites and ataxites.

The correlation of test data, producing the graph of hardness—nickel content relations, should be of considerable value in future study of iron meteorites. This graph indicates what may be expected as this investigation is pursued further.

The investigations have already produced a large amount of new information on iron meteorites and have turned now to identification of those materials that are found as inclusions. Hardness testing here is presenting a new opportunity in that chemical reactions coupled with measurements of hardness will serve to differentiate between materials which by one or the other test alone are too nearly alike for individual identification.

This investigation by microhardness testing has now produced an entirely new method of studying meteorites. The writer feels that the principles and technique of microhardness testing will be fully appreciated by those who are now engaged in meteorite study and that some may wish to carry the investigation further in their own laboratories. He will be glad to assist any investigators who do so—insofar as his experience and suggestions may be guidance for them.

In conducting this investigation, the writer has enjoyed exceptional opportunities to obtain reliable test results on bona fide meteorite specimens. For willing and untiring assistance in this work, he again is deeply indebted to Dr. H. H. Nininger of Arizona, a leading authority, who furnished the specimens for test and gave very valuable advice, and to Mr. H. Thomasson of Hamilton, Ontario, a prominent authority on metallurgy, and his capable assistant, Miss Effie M. Henderson, both of whom performed the tests on these meteorites with accurate and consistent measurements. It has been very inspiring to receive such excellent co-operation in this work, for which the writer wishes again to express his grateful thanks to these three persons who have made this investigation possible and assured its success.

OUT OF OLD BOOKS

By Helen Sawyer Hogg

The Constellations

All astronomical readers know that some of the constellations date back to very early—even prehistoric—times. However there are in the sky, particularly in the southern hemisphere, much more recent constellations. Who introduced these, and when? Which are the early constellations and which the later?

A very concise answer to this problem may be found in G. F. Chambers' "A Handbook of Descriptive Astronomy", where all the constellations are listed under their sources. A study of this list will probably clear up many points of confusion. We see at once that the best known constellations date back to Ptolemy's catalogue of 137 A.D.; presumably these were taken from the earlier star catalogue of Hipparchus. Not until the end of the sixteenth century were any other constellations added to the sky. Tycho Brahe introduced the well known Coma Berenices about the same time that Bayer, who must have been a naturalist, scattered birds and reptiles over the southern sky. Of nine constellations named for birds, Bayer is responsible for five. All the constellations Bayer added to the list are accepted to-day.

Only two constellations added by Royer in 1679, Columba and Crux, still remain. We recognize the importance of his Nubes Major and Minor, but do not regard them as separate constellations. Charles's Oak and Charles's Heart added about the same time by Halley and Flamsteed have now disappeared.

Hevelius a few years later had better success in selecting constellations, and nine of our present ones are due to him. A half century later La Caille introduced in the southern sky a list of thirteen new constellations, all of which are still accepted, though in some cases with slightly altered name. La Caille seems to have been as much interested in machinery and geometrical equipment as does Bayer in birds. We find that he was responsible for placing such curious things in the heavens as an airpump and a chemical furnace—Fornax, in which a decade ago was discovered the remarkable cluster. He also introduced the most appropriate constellation of Telescopium.

The name of Messier was once placed among the constellations. Though it does not survive there, it is permanently attached to a hundred of the most important nebulae and clusters in the sky. Even though Bode was a great astronomer, by the end of the eighteenth century the sky had been so thoroughly divided into constellations that none of the groups to which he assigned names has survived—not even his tribute to the great William Herschel in Telescopium Herschelii.

Since the time of La Caille the only new constellations to be accepted have resulted from the division of the great Argo Navis into its three constituent parts by Sir John Herschel. At present, by international agreement, 88 constellations are recognized. Our readers may find a concise alphabetical list of these, with abbreviations, on page five of the Observer's Handbook. We reprint here the lists of constellations given by Chambers, op cit., 3rd edition, 1874, pp. 554-562. To the original list of Chambers I have added numbers in order to show which constellations are still accepted. In some cases I have inserted the present name in brackets, if it is different from the old. Under Ptolemy's old constellation of Argo Navis which sprawled for seventy-five degrees across the southern sky I have added the three modern sub-divisions, Carina, Puppis, and Vela.

The International Astronomical Union has now settled the boundaries of constellations, presumably for all time, so that our readers may feel some encouragement to know that any constellations they may learn now will never be changed.

THE CONSTELLATIONS

Ptolemy enumerates 48 constellations: 21 northern, 12 zodiacal, and 15 southern, as follows:—

Northern

1. Ursa Minor.	The Little Bear.
2. Ursa Major.	The Great Bear.
3. Draco.	The Dragon.
4. Cepheus.	
5. Boötes, or *Arctophylax*.	The Bear Keeper.
6. Corona Borealis.	The Northern Crown.
7. Hercules, *Engonasin*.	Hercules kneeling.
8. Lyra.	The Harp.
9. Cygnus, *Gallina*.	The Swan.

10. Cassiopeia.	The Lady in her Chair.
11. Perseus.	
12. Auriga.	The Charioteer.
13. Serpentarius, [Ophiuchus].	The Serpent Bearer.
14. Serpens.	The Serpent.
15. Sagitta.	The Arrow.
16. Aquila, *Vultur volans.*	The Eagle.
17. Delphinus.	The Dolphin.
18. Equuleus.	The Little Horse.
19. Pegasus, *Equus.*	The Winged Horse.
20. Andromeda.	The Chained Lady.
21. Triangulum.	The Triangle.

Zodiacal

22. Aries.	The Ram.
23. Taurus.	The Bull.
24. Gemini.	The Twins.
25. Cancer.	The Crab.
26. Leo.	The Lion.
27. Virgo.	The Virgin.
28. Libra, *Cheloe.*	The Balance. *The claws* [of Scorpio].
29. Scorpio.	The Scorpion.
30. Sagittarius.	The Archer.
31. Capricornus.	The Goat.
32. Aquarius.	The Water Bearer.
33. Pisces.	The Fishes.

Southern

34. Cetus.	The Whale.
35. Orion.	
36. Eridanus, *Fluvius.*	Eridanus, The River.
37. Lepus.	The Hare.
38. Canis Major.	The Great Dog.
39. Canis Minor.	The Little Dog.
Argo Navis.	The Ship "Argo".
40. [Carina].	[The Keel].
41. [Puppis].	[The Poop].
42. [Vela].	[The Sails].
43. Hydra.	The Snake.
44. Crater.	The Cup.
45. Corvus.	The Crow.
46. Centaurus.	The Centaur.
47. Lupus.	The Wolf.
48. Ara.	The Altar.
49. Corona Australis.	The Southern Crown.
50. Piscis Australis.	The Southern Fish.

Tycho Brahe (d. 1601) added—

51. Coma Berenices.	The Hair of Berenice.
Antinoüs.	

(Both Northern Constellations.)

Bayer (d. 1603) added—

52. Pavo.	The Peacock.
53. Toucan.	The American Goose.
54. Grus.	The Crane.
55. Phoenix.	The Phoenix.
56. Dorado, *Xiphias*.	The Sword Fish.
57. Piscis Volans, [Volans].	The Flying Fish.
58. Hydrus.	The Water Snake.
59. Chamaeleon.	The Chameleon.
60. Apis, [Musca].	The Bee, [The Fly].
61. Avis Indica, [Apus].	The Bird of Paradise.
62. Triangulum Australe.	The Southern Triangle.
63. Indus.	The Indian.

(All Southern.)

Royer, in 1679, added—

64. Columba Noachi.	The Dove of Noah.
65. Crux Australis.	The Southern Cross.
Nubes Major.	The Great Cloud.
Nubes Minor.	The Little Cloud.
Fleur-de-lys.	The Lily.

(All Southern Constellations.)

Halley, about the same period, added—

Robur Caroli.	Charles's Oak.

(A Southern Constellation.)

Flamsteed's maps also contain—

Mons Maenalus.	The Mountain Maenalus.
Cor Caroli.	Charles's Heart.

(Both Northern Constellations.)

Hevelius, in 1690, added—

66. Camelopardus.	The Cameleopard.
67. Canes Venatici, *Asterion et Chara*.	The Hunting Dogs.
68. Vulpecula et Anser.	The Fox and the Goose.
69. Lacerta.	The Lizard.
70. Leo Minor.	The Little Lion.
71. Lynx.	The Lynx.
72. Clypeus, or Scutum, Sobieskii.	The Shield of Sobieski.
Triangulum Minor.	The Little Triangle.
Cerberus.	

(All Northern: and)

73. Monoceros.	The Unicorn.
74. Sextans Uraniae.	The Sextant of Urania.

(Southern Constellations.)

La Caille, in 1752, added—

75. Apparatus Sculptoris, [Sculptor].	The Apparatus of the Sculptor.
76. Fornax Chemica.	The Chemical Furnace.
77. Horologium.	The Clock.
78. Recticulus Rhomboidalis.	The Rhomboidal Net.
79. Caela Sculptoris, [Caelum].	The Sculptor's Tools.
80. Equuleus Pictoris, [Pictor].	The Painter's Easel.
81. Pixis Nautica, [Pyxis].	The Mariner's Compass.
82. Antlia Pneumatica.	The Air Pump.
83. Octans.	The Octant.
84. Circinus.	The Compasses.
85. Norma, or Quadra Euclidis.	Euclid's Square.
86. Telescopium.	The Telescope.
87. Microscopium.	The Microscope.
88. Mons Mensae, [Mensa].	The Table Mountain.

(All Southern Constellations.)

Le Monnier, in 1776, added—

Tarandus.	The Rein Deer.
Solitarius.	The Solitaire.

(The former in the Northern, the latter in the Southern hemisphere.)

In the same year Lalande placed Messier's name in the heavens, by forming a constellation in his honour, near Tarandus.

Poczobut, in 1777, added—

Taurus Poniatowskii.	The Bull of Poniatowski.

(Between Aquila and Serpentarius.)

Hell formed in Eridanus—

Psalterium Georgianum.	George's Lute.

And, finally, in Bode's maps we meet with—

Honores Frederici.	The Honours of Frederick.
Sceptrum Brandenburgicum.	The Sceptre of Brandenburg.
Telescopium Herschelii.	Herschel's Telescope.
Globus Aërostaticus.	The Balloon.
Quadrans Muralis.	The Mural Quadrant.
Lochium Funis.	The Log Line.
Machina Electrica.	The Electrical Machine.
Officina Typographica.	The Printing Press.
Felis.	The Cat.

Making in all 109 constellations. This number by no means exhausts the list of those which have been proposed by different persons. A writer in the *English Cyclopaedia* very pertinently remarks: "In fact, half-a-century ago, no astronomer seemed comfortable in his position till he had ornamented some little cluster of stars of his own picking with a name of his own making."

Sir J. Herschel said: "The constellations seem to have been almost purposely named and delineated to cause as much confusion and inconvenience as possible. Innumerable snakes twine through long and contorted areas of the heavens, where no memory can follow them; bears, lions, and fishes, small and large, northern and southern, confuse all nomenclature," &c.

Many of the above smaller constellations are very properly rejected by modern uranographers. — — —

According to Argelander, the number of stars visible to the naked eye at Berlin is 3256. The number, of course, increases as we approach the equator, owing to the wider expanse of heavens opened up by the diurnal movement.

REVIEW OF PUBLICATIONS

The Planet Mars, by Gerard Vaucouleurs, translated by P. A. Morse. 87 pages, 5½ x 8½ ins., London, Faber and Faber Ltd., 1950. Price 10s. 6d.

This very readable little book, written by an astronomer on the staff of the Astrophysical Institute of Paris, is a semi-popular account of the present state of knowledge of the planet Mars. Successive chapters deal with the general physical properties, the polar caps, the bright regions, the atmosphere, the climate, the dark regions and the canals.

An experienced planetary observer himself, the author stresses the extreme difficulty of seeing and interpreting fine details, due to the great distance of Mars. He likens the best telescopic view of Mars to what we should see of the moon were we to observe it, with the unaided eye or low power binoculars, rising over a tarred road which had been warmed all day by the sun. Yet from vast numbers of such observations, by skilled and patient observers, he concedes that much has been learned of the surface details.

Fortunately, however, various additional astrophysical methods are applicable to study Mars, its atmosphere and surface conditions. The author outlines the information derived from spectrographic, radiometric, polarimetric and other methods, over the past quarter of a century.

The book is written in a very interesting style. In places the arguments seem over-simplified. For example, in the sections on the canals, the headings "Europe Condemns the Canals", and "The Americans Defend Them" seem to be a pretty bold generalisation. Also apparently in an attempt at simplification he has omitted the specific references to the many researches he quotes; such references would have been a great aid to the many students whose interest will be aroused by the author's interesting presentation of the methods of research. The poor little moons of Mars receive scant attention.

The book could have been further enhanced by the inclusion of more plates. There are in existence many fine Martian photographs. In particular, we recall some of the more recent photographs by the Lowell astronomers, and some of the excellent multiple-print photographs by the French astronomer Lyot.

The author pleads for an intensification of Martian research at the close approach of 1956. Undoubtedly the use of large telescopes for short-exposure photography at that time will provide far finer photographic charts of the surface features than have heretofore been possible.

F.S.H.

The Star Almanac for Land Surveyors for the Year 1951; prepared by H.M. Nautical Almanac Office. Pages XIII plus 66; 6½ by 9¾ inches; paper covered. H.M. Stationery Office, London, England. Price 3s. 0d. net.

In a preface to this new annual publication by H.M. Nautical Almanac Office, the Astronomer Royal explains that this fills a long-felt need on the part of surveyors for astronomical data adequate for and suited to their purpose. The new star almanac was therefore designed to provide "precisely what the surveyor wants, in the least space and without any unwanted material".

The surveyor uses observations of the sun and stars to fix position and direction with precision. To reduce his observations he requires precise day by day data on the positions of the sun and a sufficient selection of stars. These are provided in the two main tables of the Star Almanac. The first, Ephemeris of the Sun, gives for every 6 hours throughout the year, the quantities R, (quantity to be added to Greenwich Mean Time), declination of the Sun, and E (quantity to be added to Greenwich Mean Time to give Greenwich Hour Angle of the sun). The second table gives Right Ascensions and declinations monthly throughout the year for 650 stars which include all stars down to 4th magnitude and some additional stars in the interval $4^m.0$ to $4^m.5$. With these two tables the surveyor quickly obtains the declination and Greenwich Hour Angle or Local Hour Angle as required for position or azimuth determinations. The remaining smaller tables are as follows: 10-day positions of five circumpolar stars, Index to Places of Stars, Pole Star Table (data for obtaining latitude and azimuth), Refraction Tables, various interpolation tables supplementing the main tables, and a conversion table of time to arc.

By virtue of its completeness, conciseness and handy size, the *Star Almanac for Land Surveyors* should be a welcome innovation for professional and amateur surveyors.

J. F. H.

MEETINGS OF THE SOCIETY

AT EDMONTON

February 9, 1950.—The meeting was called to order by the President at 8:22. The minutes of the last meeting were read and approved. It was moved by Mr. Stockwell, seconded by Mr. Keeping and carried that the Associate fee be raised to 75 cents. Mr. Carl Nelson, Box 171, University of Alberta, was elected as an Associate member. The Handbook talk was given by Dr. Campbell. Mr. Burt gave a report on the activities of the other centres, including some quotations from "Skyward".

The main paper was given by Mr. J. J. Gillis on "Solar and Cosmic Radio Noise". In 1931 Jansky observed at a frequency of 205 megacycles that static seemed to come from the centre of our galaxy. Another case occurred in British radar interference, when all apparatus was found to be facing the setting sun. Microwave telescopes have been constructed. They consist of an antenna at the focus of a parabolic reflector, an amplifier, and means of making the signal audible or visible on a cathode ray screen. A comparison of properties from various points of view was made between optical and microwave telescopes. After a series of observations it can be stated that cosmic noise: (1) exists in all directions, (2) is strong in plane of galaxy, (3) is strongest from centre of galaxy.

Measured intensities are less certain but some information is available. A matched black-body temperature gives an easy way of referring to intensity measurements. Some radiation comes directly from the solar disc, partly from sun-spots. This was checked at the solar eclipse in 1946. Within minutes of the occurrence of a solar flare, radio fade-outs, magnetic storms, and other disturbances on the earth are observed. The task ahead is to find an explanation of these extraordinary radiations from cosmic space and from the sun. A theory for the sun as a source is hopeful but not entirely satisfactory, as yet.

The meeting adjourned after questions and comments to Room 111 for refreshments. There were 28 members and visitors present.

March 9, 1950.—The meeting was called to order at 8:20 by the Vice-president, Mr. Deane. The minutes of the last meeting were read and approved. An application was received from Dr. W. W. Happ, 10841–85 Ave., the usual motion instructing the secretary to cast a ballot electing the new member was moved, seconded and passed unanimously. Mr. H. M. Burt read about a contact with South America and other items from "Skyward". The Handbook talk was given by Dr. Campbell.

The main paper was given by Mr. L. E. Gads on the subject "Time Finders and Time Keepers". Last year the Bureau of Standards, Washington, D.C., announced an atomic clock with an accuracy of one in 20 million, with an anticipated accuracy of 1 in 10 billion, or one second in 300 years. Utilizing the resonance frequency of the atoms of nitrogen in molecules of ammonia gas, the clock was based on a principle which was declared unlikely to be successful only 20 years ago by the Encyclopaedia Britannica.

It is interesting to review the evolution of not only clocks and the means of time keeping, but the evolution of the whole concept of time, its meaning and its role in our daily lives. It is tempting to cite such early philosophers as St. Augustine who have inquired into the very nature of past, present and future. As the means of communication and transportation became more rapid the need of accurate time measurement became more important. The most natural time keepers were the heavenly bodies. The sun-dial served as the time-finder and the sand clock and the water clocks were used as time-keepers. The evolution of mechanical devices for keeping time is interesting to trace. Not until the pendulum was introduced, was it possible to keep time correctly. Improvements in the methods of observational astronomy made it possible to establish correct instants of time, but not until the early thirties, when crystal clocks were first introduced, was it possible to check the rate of rotation of the earth itself. The final development of the atomic clock produces an absolute standard of time, independent of the heavenly bodies.

After some questions and discussion the meeting adjourned at 9:55. There were 35 members and visitors present.

April 18, 1950.—The meeting was called to order at 8:19. An application was received from Fred Jensen. The usual motion instructing the secretary to cast a ballot electing the new member was moved, seconded and passed unanimously. The Handbook talk was given by Dr. Campbell.

The main paper of the evening was given by S./L. W. A. Hockney, on the subject of "Navigation", with special reference to difficulties encountered in polar regions. Various straightforward aids to navigation were outlined, such as use of wind drift, sights on earth points, and sights on celestial bodies. Some detail was given about the course and true air-speed velocity, and their relation to the wind speed which is given in m.p.h. but is needed in knots. The resultant velocity is the track and the so-called ground speed. Some explanation was given of a great circle and rhumbline tracks. Knowledge of four out of six variables in a spherical triangle enables the other remaining two to be read from a mechanical calculator and thus the position of the aircraft can be determined.

There are many aids to navigation and some of these were mentioned and a few described. There are topographical maps and charts. Magnetic compasses are greatly used but are unreliable north and east of a line from Aklavik through Bear Lake to Eskimo Point. Mention was made of the astro-compass, a special drift meter, the altimeter, the astrograph and the use of position lines and their intersections. Under the special heading of radio ideas there are loran stations, and search radar with plan position indicator. Two altmeters use radar principles, one using F.M. good from 0 to 4000 feet, and a radar altimeter using a pulse, good from 0 to 50,000 feet. Special mention was made of the difficulties in polar regions and it was suggested that this kind of navigation is not only a science but something of an art. An example was worked out showing a flight from Norman Wells to Archangel. The great circle line varies in bearing from 7° to 173° and is changing continually during the flight. Topographical maps of north areas are still not detailed or very accurate. Some new polar projections and plotting charts are available. There are good directional gyros but these are still subject to "wander". A method called grid navigation has

been worked out. It can be said that a combination of gyro and grid navigation is now the best basis. There are special tables for rapid computations in the reduction of sights. Natural conditions have their effect too. For 6 weeks each way of December 22 the north is dark and star shots can easily be taken but on either side of that there are 6 weeks of twilight which makes observation very difficult.

There was a short period for questions and the meeting adjourned at 10:05 for refreshments as usual. There were 25 members and visitors present.

May 11, 1950.—The meeting was called to order by the Vice-president at 8:15 p.m. The minutes of the previous two meetings were read and approved with one amendment. Mr. H. M. Burt discussed the material on two issues of Skyward, the Montreal Centre pamphlet. The Montreal Centre seemed very well satisfied at the circulation their newsletter was achieving in Western Canada. Many wonders of the heavens including Lyrid meteors and sun dogs were discussed.

The main part of the programme was taken by Dr. Campbell who introduced slides and a moving picture by a short talk on the scale of the universe. During the showing of slides of various features of the heavens including some of the most distant nebulae, explanatory remarks were given where necessary. Finally a repeat of the McMath-Hulburt moving picture showing the behaviour of solar prominences was enjoyed by both old and new members.

The meeting adjourned for refreshments about 9:30 and following that a number of the audience went to the Observatory where they had an opportunity to see the planet Saturn through the Wates telescope. There were 29 members and visitors present.

E. H. GOWAN, *Honorary Secretary.*

AT VICTORIA

December 14, 1949.—The Annual Meeting took the form of a dinner meeting held at "Terry's" at 6:50 p.m. The president, Dr. J. Stevenson, was in the chair. About 73 members and friends were present. Vocal solos were rendered by Mr. Pierre Timp, accompanied by Mrs. Timp. Reports were received from the Recorder, Secretary-treasurer, Librarian, Director of Telescopes and the scrutineers.

The president introduced the speaker of the evening, Professor R. Wallace, of the Department of Mathematics, Victoria College, who delivered a comprehensive lecture on "The Nature of Proof". A number of types of proof were outlined: argument, senses, legal, natural sciences, induction and opposed to these, deduction, or the mathematical method. According to Webster, anything that convinces the mind is *proof.* Mathematics was entirely a human invention based on how, when, why and where. The principles of the nature of proof were traced from ancient times down to the present theories of a mathematical nature, using the case of "the male barber who shaved all in his village who did not shave themselves". Does the barber shave himself? The answer to this is "He does when he doesn't and doesn't when he does"!

Dr. J. A. Pearce expressed the thanks of the meeting, saying, "Now all is clear; the mathematicians attained Nirvana in the invention of the zero and after contemplating the symbol for hundreds of years, now knew everything about nothing, which is where they have an advantage over ordinary folk who know nothing about everything".

January 11, 1950.—The meeting was held at Victoria College, Dr. J. Stevenson presiding. A committee of Messrs. E. H. Pope, F. R. Williams, Dr. R. Petrie and R. Peters was appointed to arrange for the ceremony of renaming the Brydon Telescope in April.

Dr. Anne Underhill, astronomer at the Dominion Astrophysical Observatory, addressed the meeting on "Astronomy in Post-War Europe". This was a most interesting account of the speaker's experiences as a student and research worker with special reference to the University of Copenhagen where she made special studies of stellar atmospheres under Professor Strömgren. The age and historical interest of the European observatories were emphasized. Slides illustrated the lecture.

Mrs. Chesman expressed the thanks of the meeting to the speaker.

February 8, 1950.—The meeting was held at Victoria College, Dr. J. Stevenson presiding. Dr. Petrie outlined methods of determining stellar distances, which included investigations which he is undertaking at Saanich mountain.

The speaker of the evening was Mr. Ian Williams, M.Sc., of the Department of Mines, B.C. He spoke on "The Detection of Radioactive Ores". Geiger counters, electrometers, and scintillation counters were treated and fully described. The characteristics of phosphors and photo-multiplier tubes were revealed. Professor Kleimenhager expressed the appreciation of the meeting.

ROBT. C. FAIRALL, *Recorder.*

AT OTTAWA

January 23, 1950.—The first meeting of the 1950 lecture series was held on Monday evening, January 23, at the Carleton College Assembly Hall, with the president, Dr. Peter M. Millman, in the chair. He announced several new members, Mr. C. H. Ney, Mr. V. N. Bruce, and Mr. L. G. Smith; and introduced Mr. M. M. Thomson, who spoke briefly on the question of the beginning of the second half of this century.

The president then introduced the principal speaker, Dr. Ernest A. Hodgson, who told about his trip to the Seventh Pacific Science Congress in "Down Under in New Zealand". By using a number of slides, Dr. Hodgson recounted his trip across to the Pacific Coast, by air to New Zealand, and around the islands, visiting many places of particular note. With the emphasis laid on local customs, the evening was most interesting and informative.

Dr. D. A. MacLulich moved a vote of thanks which was seconded by the Honourable James Thorne, High Commissioner for New Zealand, who told of a few personal experiences during earthquakes.

February 6, 1950.—The second meeting was held on Monday evening, February 6, at the Carleton College Assembly Hall, with the president in the chair. He announced a new member, Mrs. E. F. Burton, and gave some general information about the society for those in the audience who were not members. The recently announced explosion on Mars was referred to and it was noted that this might have been due to a very large cloud, perhaps of water vapour or ice crystals, lying high in the Martian atmosphere.

The president then introduced the principal speaker of the evening, Dr. J. A. Rottenberg, of the Dominion Observatory, whose topic was "The Origin of the Solar System". After a general survey of the problem, Dr. Rottenberg discussed a number of specific theories, from the earlier ones by Kant and Laplace, through that of Jeans-Jeffries, to those of Hoyle and von Weizsäcker. It was pointed out that none of these gave a complete explanation, but that work to be done in the next few years may clarify the situation and bring us much closer to a solution. The lecture was well illustrated with slides.

Dr. T. L. Tanton proposed a vote of thanks to the speaker.

February 20, 1950.—The third meeting was held on Monday evening, February 20, at the Carleton College Assembly Hall, with the president in the chair. He welcomed the members and their friends, and mentioned that the Society's *Handbook* gives interesting information about Mars and Jupiter, now coming into view.

The president then introduced the principal speaker, Dr. Leslie E. Howlett, M.B.E., F.R.S.C., Associate Director of the Division of Physics of the National Research Council, who spoke on "Some Canadian Contributions to Physics". Important among these is work in connection with lenses for aerial photography. Large aperture lenses developed for astronomical purposes are unsuitable, as a good image is required over a field approximately ninety-six degrees in diameter instead of one or two degrees, while the effect of coloured light on a film is radically different from its effect on the eye. Because of this, new standards must be found for testing lenses for aerial photography. Also in connection with optics, a high speed motion-picture camera has been developed that will take over 100,000 frames a second, and a short film was shown to illustrate this. Other work, in the field of acoustics, has been concerned with increasing the efficiency of the marine fog horn, and, in the applications of atomic radiation to everyday life, considerable success has been obtained by the use of Cobalt 60 in the testing of welds, and in the treatment of cancer by various radio-active elements. The speaker answered a number of questions from members of the audience.

Dr. C. S. Beals proposed a vote of thanks to Dr. Howlett.

MARGARET ANN MCKEE, *Assistant Secretary.*

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